AMENDMENT TO THE SPECIFICATION

Replace the paragraph beginning on page 6, line 21 with the following paragraph:

FIG. 2 depicts a block diagram of a Multiple Input Multiple Output (MIMO) system 200. The MIMO system ~~202~~ 200 is an N-user data transmission system. The MIMO system 200 receives input CAP signals $a^{(1)}(n)$, $a^{(2)}(n)$ and so on up to $a^{(N)}(n)$. The MIMO system 200 comprises a transmit filter 204 which receives each of the input cap CAP signals $a^{(1)}(n)$ through $a^{(N)}(n)$ and imparts thereto a filtering function G(f), communications channels having impairments 206 which are represented by a function H(f), a summer 208 and receive filters 210 which implement a function R(f). The output of the ~~received~~ receive filters 210 comprises output signals $a'^{(1)}(n)$, $a'^{(2)}(n)$ and so on up to $a'^{(N)}(n)$.

Replace the paragraph beginning on page 9, line 2 with the following paragraph:

FIG. 3 depicts an illustrative example of interference between communication channels such as those depicted in the ~~of the~~ communication system of FIG. 1. Specifically, FIG. 3 depicts a functional representation of two communication channels in which interference is imparted from at least one channel to the other. A first communication channel i comprises a pre-coder function 310_i, a summer function 320_i, a transmit filter function 330_i, a first channel impairment function 340_i, a second channel impairment function 345_i, a second summer 350_i, a received filter function 360_i. Similarly, the second channel j comprises ~~comprises~~ a pre-coder function 310_j, a summer function 320_j, a transmit filter function 330_j, a first channel impairment function 340_j, a second channel impairment function 345_j, a second summer 350_j, a received filter function 360_j.

Replace the paragraph beginning on page 9, line 14 with the following paragraph:

Each of the channels i and j receive a respective transmit CAP signal or symbol stream, denoted as $a^{(i)}(n)$ and $a^{(j)}(n)$, respectively. Each received transmit CAP symbol stream is coupled to the respective pre-coder function 310 and a first input of the summer function 320. The output of each pre-coder function 310 is coupled to a

second input of the summer function of the opposite channel. That is, the output of decoder function 310_i is coupled to a second input of summer function 320_j, while the output of pre-coder function 310_j is coupled to a second input of summer function 320_i. The output of each of the first summer functions 320 is coupled to the respective transmit filter function 330. The outputs of the respective transmit filter functions 330 are coupled to respective inputs of respective channel impairment functions 340 and 345. The output of respective channel impairment functions 340 are coupled to first inputs of respective second summer functions 350. The output of channel impairment function 345_i is coupled to a second input of second summer function 350_j. The output of second channel impairment function 345_j is coupled to a second input of second summer function 350_i. The output of the second summer functions 350 is coupled to channel respective inputs of receiver functions 360. The output of the respective receiver filter functions 360 comprises output signals $a'^{(i)}(n)$ and $a'^{(j)}(n)$. These output signals may be switched at a rate of 1/T to produce corresponding signals ~~â to i(n) and â to j(n)~~ $\hat{a}^{i}(n)$ and $\hat{a}^{j}(n)$.

Replace the paragraph beginning on page 10, line 4 with the following paragraph:

Since $H(f)$ is unknown, direct computation of $P(f)$ is not feasible, since the matrix P(f) depends on the impairment matrix H(f). However, $\mathbf{P}(f)$ is found based on iterative methods according to an embodiment of the invention. By starting with $\tilde{\mathbf{P}}(f)$ in place of $\mathbf{P}$(f) and <u>varying</u> $\tilde{\mathbf{P}}(f)$ until the mean-square-error at the slicer of receiver 108 is minimized, then $\tilde{\mathbf{P}}(f)$ is a reasonable first approximation of $\mathbf{P}(f)$. $H(f)$ cannot necessarily be predicted accurately. A predetermined CAP signal has to be transmitted and the received CAP signal can be measured to determine errors in the received CAP signal.

Replace the paragraph beginning on page 11, line 9 with the following paragraph:

FIG. 4 depicts a high level block diagram of a multiple channel transmission system according to an embodiment of the present invention. It will be appreciated by those skilled in the art that while the system 400 of FIG. 4 is depicted as including four

encoding, transmitting and receiving entities, more or fewer encoding, transmitting and/or receiving entities may be utilized.

Replace the paragraph beginning on page 12, line 4 with the following paragraph:

Referring to channel *A* in the system 400 of FIG. 4, the transmitter includes an encoder E_1 that produces an encoded symbol stream of the form $a^{(1)}(n)$ in response to a received data signal DS_1. The encoded symbol stream is provided to a summer S_1. The summer S_1 also receives three other signals provided by respective pre-coders. A first pre-coder $P_{12}(f)$ receives an encoded signal $a^{(2)}(n)$ produced by an encoder E_2 of the second transmitter. Similarly, the second $P_{13}(f)$ and third $P_{14}(f)$ pre-coders receive encoded signals from the third E_3 and fourth [[E4]] $\underline{E_4}$ transmitters. Each of the pre-coders $P_{12}(f)$ through $P_{14}(f)$ provides a respective pre-coded output signal $u^{(12)}(n)$ through $u^{(14)}(n)$ to the summer S_1. The summer S_1 sums the encoded signal produced by the encoder E_1 and the signals produced by the three pre-coders to produce an output signal [[$v^{(1)(n)}$]] $\underline{v^{(1)}(n)}$ that is coupled to the first transmitter filter $G_1(f)$. The output of the transmitter filter $G_1(f)$ is transmitted by a respective channel to a corresponding receiver $R_1(f)$.

Replace the paragraph beginning on page 14, line 26 with the following paragraph:

In a preferred embodiment of the invention, the initial pre-coder operating parameters are determined entirely at the respective receivers. Specifically, FIG. 5 depicts a high level block diagram of the multiple channel transmission system of FIG. 4 further modified to include receiver side pre-coders. In one embodiment of the invention, the system of FIGS. 4 and 5 operate in a training mode as depicted with respect to FIG. 5, followed by a normal operating mode as depicted by FIG. 4. The system 500 of FIG. 5 differs from the system 400 of FIG. 4 in that each of the receivers within the system 500 of FIG. 5 further comprises three respective pre-coders and summing means adapted to summing the output of the respective pre-coders and a received signal. In addition, the adaptation algorithms *AA* of the respective receivers are modified to enable to adaptation of pre-coder matrix or matrices for the receiver pre-

coders such that in a training mode the receiver may itself rapidly determine at least an initial, if not optimal, pre-coder operating parameter set for the transmitter-side pre-coders.

Replace the paragraph beginning on page 15, line 10 with the following paragraph:

Referring now to FIG. 5, each of the encoders E_1 through E_4 provides a predetermined training sequence of the form $a^{(i)}(n)$ to its respective receiver via its respective channel. The predetermined training sequence is known to each of the respective receivers. It is noted that the receiver equalizers *R(f)* may also be trained. However, the training of receiver equalizers is beyond the scope of the present invention, since such receiver equalizer training depends entirely upon the particular implementation of the receiver, and since the teachings of the present invention may be successfully employed using many different receiver equalizer implementations. Referring to FIG. 5, at each receiver a substantially identical predetermined training sequence of the form $a^{(i)}(n)$ is coupled to the receiver differencer *D*. The training signal transmitted from the respective transmitter through the respective channel is received by the receiver equalizer *R* and coupled to a receiver summing element *SR*. Additionally, each of the three pre-coder elements representing channel impairments caused by each of the three other channels provide respective output signals (in response to respective input training sequence or matrix values) which are also coupled to the receiver summing element *SR*. The output of the receiver summer *SR* is provided to a differencing element *D*, where it is compared to the known predetermined training sequence. Difference data [[*B*]] <u>e(n)</u> is coupled to the adaptation algorithm *AA*, which responsively adapts one or more of the pre-coder functions and/or the receiver function.

Replace the paragraph beginning on page 16, line 28 with the following paragraph:

The pre-coders are modeled as complex input, complex output, symbol spaced FIRs. There are 12 pre-coders in this four-user system. Each pre-coder has,

illustratively, three complex tap coefficients that are adaptive. To describe the detail of operation of the pre-coder, we first define a vector, as follows:

$$\mathbf{a}'(n)=\left[a(n),a(n-1),a(n-2)\right] \qquad \text{(equation 8)}$$

as the vector of complex symbols in the delay line at the n-th sampling instant, and

[[$\mathbf{c}^T(n)=\left[c_0(n),c_1(n),,c_2(n)\right]$ (equation 9)]]

$\underline{\mathbf{c}^T(n)=\left[c_0(n),c_1(n),c_2(n)\right]}$ <u>(equation 9)</u>

as the vector of complex tap coefficient ~~at t he~~ <u>at the</u> n-th sampling instant.

Replace the paragraph beginning on page 20, line 27 with the following paragraph:

FIG. 10 depicts a high level block diagram of an embodiment of a controller suitable for use within a transmitter. Specifically, FIG. 10 depicts a high level block diagram of a transmitter 104 suitable for use in the communication system 100 of FIG. 1. The voice transmitter controller 104C comprises a microprocessor 1020 as well as memory 1030 for storing programs 1050 such as <u>the</u> pre-coding method ~~500~~ which was described more fully above in a discussion of FIG. 5. The microprocessor 1020 cooperates with conventional support circuitry 1040 such as power supplies, clock circuits, cache memory and the like as well as circuits that assist in executing the software methods of the present invention.